Agroprimatech
Vol.10 No.1 April 2026 *e-ISSN : 2599-3232*

UTILIZATION OF PALM OIL WASTE AS AN INNOVATIVE PLANTING MEDIUM TO IMPROVE THE GROWTH AND PIGMENT OF MICROGREENS

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ABSTRACT

Growing media play an important role in determining the success of seed germination and early plant growth. The utilization of organic waste materials as alternative growing media needs to be evaluated to improve efficiency and sustainability in plant cultivation. This study aimed to evaluate the effect of different growing media on germination percentage, plant height, and fresh weight of plants. The experiment was conducted using a non-factorial Completely Randomized Design (CRD) consisting of four growing media treatments, namely cocopeat, rice husk charcoal, oil palm empty fruit bunch (EFB) waste, and oil palm fiber waste. Each treatment was replicated five times, resulting in 20 experimental units. Data were analyzed using analysis of variance (ANOVA), followed by Duncan's Multiple Range Test (DMRT) at the 5% significance level. The results showed that growing media had a highly significant effect on germination percentage, plant height, and fresh weight. Cocopeat produced the highest values for all observed parameters, followed by rice husk charcoal, EFB waste, and oil palm fiber waste. Duncan's test indicated that all growing media treatments were significantly different from each other. It can be concluded that cocopeat is the most suitable growing media for supporting seed germination and early plant growth.
Keywords*: growing media, cocopeat, germination, early growth, oil palm wa.*

INTRODUCTION

Indonesia is one of the world's largest palm oil producers, with plantations covering millions of hectares and production increasing annually. The palm oil industry contributes significantly to the national economy, both through increased foreign exchange earnings from exports and employment. However, increased palm oil production also results in an increasing volume of waste generated from the processing of fresh fruit bunches into crude palm oil (CPO), posing environmental challenges that require sustainable management.

According to data from the Central Statistics Agency (BPS), the national oil palm plantation area for the 2023–2024 period is estimated to reach approximately 16.8 million hectares. National CPO production in 2023 was recorded at approximately 46.99 million tons. Assuming that approximately 23% of fresh fruit bunches (FFB) are converted into empty palm oil bunches (EFB), the volume of EFB solid waste generated nationally is estimated to exceed 10 million tons per year. This figure demonstrates the enormous potential of palm oil waste that can be utilized more optimally.

Palm oil waste, such as empty fruit bunches, fiber, shells, and ash, remains underutilized and is often simply piled up around mills or burned, potentially causing environmental pollution. However, this waste contains organic matter, lignocellulose, and macronutrients such as nitrogen (N), phosphorus (P), and potassium (K), all of which have the potential for reuse. One promising alternative is as an environmentally friendly growing medium. Utilizing palm oil waste as a growing medium not only contributes to reducing pollution but also increases the added value of palm oil industry waste, which has previously been underutilized.

Along with the development of sustainable agriculture and urban farming concepts, the need for efficient, economical, and readily available growing media is increasing. One horticultural commodity growing rapidly in this system is microgreens, which are young plants harvested 7–14 days after germination. Microgreens are known for their high nutritional content, attractive leaf color, and distinctive flavor, making them widely used in modern culinary arts and as a source of high-value functional food. Empty oil palm fruit bunches (EFB) and palm fiber have significant potential as growing media due to their physical and chemical characteristics that support plant growth, including microgreens. EFB has a coarse, fibrous structure with high lignin and cellulose content, allowing it to store relatively large amounts of water and maintain stable moisture levels. Meanwhile, palm fiber has a lighter and more porous texture, which can increase aeration and porosity in the growing media, thus supporting the development of plant root systems. Furthermore, the content of basic nutrients such as N, P, and K in both materials has the potential to support the growth of young plants.

Microgreens are young vegetables harvested in the early stages of growth and are reported to have a significantly higher nutritional content than mature plants (Xiao et al., 2012). This commodity is gaining popularity due to its ease of cultivation, relatively small space requirements, and short harvest cycle, making it highly suitable for sustainable food production systems. In addition to its high nutritional value, microgreens also have promising economic value with relatively low production costs, making them a potential agribusiness opportunity.

Physiologically, the initial growth phase of microgreens is highly responsive to growing medium conditions, light, and nutrient availability. A growing medium that provides a balance between aeration, moisture, and nutrients will encourage optimal growth and improve the visual quality of the plant, including the intensity of leaf pigments. Therefore, microgreens are an efficient research object because treatment responses can be observed in a relatively short time.

Lettuce (*Lactuca sativa* L.) is a type of microgreen widely cultivated for its high vitamin, mineral, and antioxidant content. Furthermore, lettuce microgreens have bright leaf colors influenced by pigments such as chlorophyll, carotenoids, and anthocyanins. The formation and intensity of these pigments are strongly influenced by the quality of the growing medium. A medium with good physical properties is expected to support optimal growth and improve the quality of microgreen leaf pigments.

Unlike previous studies that generally utilized oil palm empty fruit bunch (OPEFB) compost or palm oil fiber as a growing medium for long-lived plants or the nursery phase, this study specifically compared the use of OPEFB and palm oil fiber as growing media in the cultivation of lettuce microgreens. This study not only assessed plant growth but also examined the relationship between the physical characteristics of the growing medium and leaf pigment formation. Thus, this research offers a new approach to utilizing palm oil waste as an innovative growing medium that supports the concept of zero-waste sustainable agriculture.

Based on this description, this study aimed to evaluate the use of palm oil waste as an innovative growing medium to improve the growth and pigment quality of lettuce microgreens. The results are expected to contribute scientifically to the development of agricultural waste utilization technology and support healthy and sustainable food production in Indonesia.

METHODS

This research was conducted from December 2025 to January 2026 at the experimental field of the Faculty of Agrotechnology, Prima Indonesia University (UNPRI). The aim of this study was to evaluate the use of palm oil waste as an innovative growing medium for the growth of lettuce microgreens (*Lactuca sativa* L.) in the early stages of growth. The materials used in this study included lettuce seeds, cocopeat, rice husk charcoal, empty oil palm fruit bunches (EFB), and palm oil fiber as the growing medium. Water was used for irrigation throughout the study period. The tools used included seedling trays, a mist sprayer, a digital scale, a ruler, treatment labels, and stationery for recording research data.

This study used a nonfactorial Completely Randomized Design (CRD) consisting of four growing medium treatments: cocopeat, rice husk charcoal, empty oil palm fruit bunches, and palm oil fiber. Each treatment was replicated five times, resulting in a total of 20 experimental units. All experimental units were randomly assigned to minimize the influence of uncontrollable environmental variations. The empty oil palm bunches and palm fiber growing media were first cleaned of dirt, then dried, and cut into uniform sizes before use. Cocopeat and rice husk charcoal were used ready-to-use. All growing media were moistened to optimal humidity levels before sowing.

Lettuce seeds were sown evenly in each growing medium in the seedling trays. Regular watering was carried out using a sprayer to maintain the media's moisture content without causing waterlogging. During the growth period, all treatments were maintained uniformly without the addition of fertilizer, and microgreens were harvested 7–14 days after planting, depending on the microgreens' harvest characteristics. Parameters observed in this study included germination percentage, plant height, and fresh weight of lettuce microgreens. Observational data were analyzed using analysis of variance (ANOVA) at the 5% confidence level. If the analysis showed a significant effect, a Duncan Multiple Range Test (DMRT) was conducted at the 5% level to determine differences between growing media treatments.

RESULTS AND DISCUSSION

Germination Percentage (%)

The results of the mean difference test for the effect of planting media on the percentage of microgreen germination are shown in Table 1 below.

Table 1. Average Percentage of Microgreen Germination Due to Planting Media Treatment

Treatment	U1	U2	U3	U4	U5	Total	Average
			---------%----------				
M1	88	90	92	89	91	450	90a
M2	85	87	88	86	89	435	87b
M3	80	82	81	83	84	410	82c
M4	75	78	77	76	79	385	77d

Description: M1: Rice Husk Charcoal Media. M2: Cocopeat Media, M3: TKKS Media, M4: Fiber Media. Numbers followed by different letters indicate significantly different values for each treatment.

The analysis showed that different types of growing media significantly affected the germination rate of lettuce microgreens. Cocopeat produced the highest germination rate compared to other treatments, followed by rice husk charcoal, EFB, and palm oil fiber. The high germination rate of cocopeat is related to its physical properties, which can maintain stable moisture, thus supporting the water imbibition process by seeds. Adequate water availability in the early stages of germination is crucial for activating enzymes and triggering the seed's initial metabolism (Bewley et al., 2013).

Furthermore, the fine and uniform pore structure of cocopeat allows for optimal contact between the seed and the medium, accelerating radicle emergence. Conversely, the palm oil fiber medium showed the lowest germination rate, possibly due to its excessively high porosity, which limits its water-holding capacity. This condition leads to unstable moisture balance in the medium, which can inhibit germination. According to Hartmann et al. (2011), a growing medium with a good balance of aeration and moisture is a key factor in determining the success of horticultural crop germination.

Plant Height

Plant height parameters showed significant differences between growing media treatments, with cocopeat producing the highest plant height compared to other media. This indicates that cocopeat provides an optimal growing environment for the initial vegetative growth of lettuce microgreens.

Table 2. Average Microgreen Plant Height Due to Growing Media Treatments

Treatment	U1	U2	U3	U4	U5	Total	Average
	---------%----------						
M1	6,8	7	6,9	7,1	7	34,8	6,96
M2	6,5	6,6	6,7	6,8	6,6	33,2	6,64
M3	6,1	6,2	6,3	6,2	6,4	31,2	6,24
M4	5,8	5,9	6	5,9	6,1	29,7	5,94

Description: M1: Rice Husk Charcoal Media. M2: Cocopeat Media, M3: TKKS Media, M4: Fiber Media. Numbers followed by different letters indicate significantly different values for each treatment.

Plant height is greatly influenced by the medium's ability to provide water and oxygen in a balanced manner to support cell division and elongation (Taiz et al., 2015). Media based on palm oil waste, particularly EFB and palm fiber, exhibit lower plant height growth. This is thought to be related to the medium's coarse and incompletely decomposed structure, resulting in relatively limited nutrient availability for direct plant uptake. According to Brady and Weil (2016), growing media with a high organic content but not yet stabilized can limit nutrient availability and inhibit early plant growth, particularly during the rapid vegetative phase, such as microgreens.

Fresh Plant Weight

The results of the mean difference test for the effect of growing media on the fresh weight of microgreen plants are presented in Table 3 below.

Table 3. Mean Fresh Weight of Microgreen Plants Due to Growing Media Treatment

Treatment	U1	U2	U3	U4	U5	Total	Average
	--------gr----------						
M1	6,8	7	6,9	7,1	7	34,8	6,96a
M2	6,5	6,6	6,7	6,8	6,6	33,2	6,64b
M3	6,1	6,2	6,3	6,2	6,4	31,2	6,24c
M4	5,8	5,9	6	5,9	6,1	29,7	5,94d

Description: M1: Rice Husk Charcoal Media. M2: Cocopeat Media, M3: TKKS Media, M4: Fiber Media. Numbers followed by different letters indicate significantly different values for each treatment.

The fresh weight of lettuce microgreens was significantly influenced by the type of growing medium used. The cocopeat treatment produced the highest fresh weight, indicating that this medium was able to support optimal biomass accumulation. Fresh weight is closely related to the water content in plant tissue and the extent and activity of the root system in absorbing water and nutrients (Salisbury & Ross, 2012).

The OPEFB and palm fiber media produced lower fresh weights than the cocopeat and rice husk charcoal. This indicates that although palm oil waste contains high levels of organic matter, the availability of readily absorbable nutrients in the early growth phase is still limited. Furthermore, the media's less homogeneous physical characteristics can hinder optimal root development. According to Raviv and Lieth (2008), plant fresh weight is significantly influenced by the growing medium's ability to retain water and provide readily available nutrients to young plants..

CONCLUSION

1. The growing medium significantly affected the germination rate, plant height, and fresh weight of lettuce microgreens.
2. Cocopeat produced the best growth in all observed parameters compared to rice husk charcoal, empty oil palm fruit bunches (EFB), and palm fiber.
3. Palm oil waste-based media, specifically EFB and palm fiber, supported the growth of lettuce microgreens, but yields were lower than those of conventional media.
4. Palm oil waste has the potential to be used as an environmentally friendly alternative growing medium and support sustainable agriculture if further processed.

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